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VARIATION IN WORKER BROOD CELL WIDTHS AND COMB ORIENTATION IN AN EXPOSED HONEY BEE NEST IN BERKELEY, CALIFORNIA

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Abstract.—Measurements taken on widths of worker brood cells in combs supported mainly at the top indicate variation in cell widths is associated with the orientation of the cell rows and comb to gravity. Cell rows with one set of the parallel sides oriented horizontally have the widths significantly larger than widths taken along other diagonal rows. If this variation in cell width according to row orientation proves to be common in suspended natural combs, then an average based on all three diagonal rows should be required when cell widths are used to identify the racial origin of bees.

Key Words.—Insecta, Hymenoptera, Apidae, Honey bee, *Apis mellifera,* worker brood cell, comb, nest variation

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This report describes an exposed honey bee nest in which worker brood cell widths varied according to orientation of the rows and comb to gravity. In 1987, a large nest was noticed at a height of about 7 m near the top of a living Coast Live Oak (*Quercus agrifolia* Neé) on the campus of the University of California in Berkeley. Large numbers of bees were seen on the nest during the summers of 1987 and 1988. In the spring of 1989, however, the nest had few active bees, probably as a result of unusual winter periods of several days near freezing. On 1 June, the nest was treated with the pesticide fenvalerate, cut down, and placed in a freezer for future examination.

METHOD

The hexagonal cells of comb form a regular pattern of three diagonal rows set at 60° to each other (Fig. 1). The orientation of the rows with reference to gravity can be described by viewing the surface of the comb in its normal, vertical position and placing a 360° circular protractor over the cells. With 0° at the top and reading clockwise, the position of each row can be given an angular designation within the first 180°. In natural comb one of the rows may be oriented nearly parallel to the force of gravity. This is the 0° row, and reading clockwise are the 60° and 120° rows. The 0° row has one pair of its three pairs of parallel walls horizontal, hence this has been called the "horizontal" orientation of a comb (Wedmore 1929). An equally frequent orientation is with the first row at 30° and the other rows at 90° and 150°. In this orientation, the 90° row has one pair of its walls vertical. This is the "vertical" orientation of comb familiar in artificial comb foundation. Other intermediate orientations are reported to be less frequent (Thompson 1930).

The widths of worker brood cells were measured on horizontal combs (combs 4 and 6) and a vertical comb (comb 5). Five subsamples of 10 linear cells each were measured in each of the three row diagonals on each side of each brood

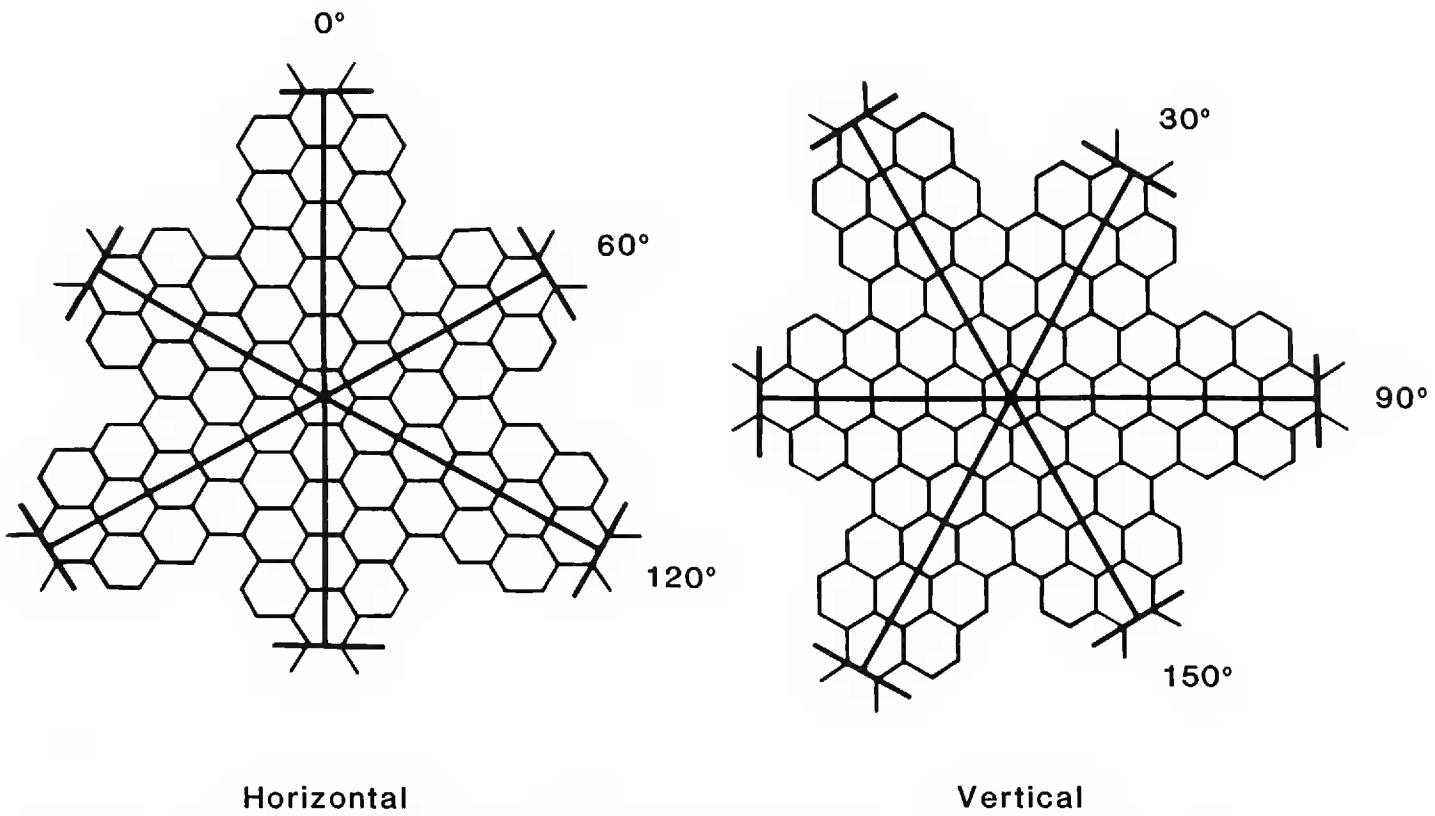

Figure 1. Horizontal and vertical orientations of cell rows in comb with 10 cells on each diagonal delimited for measurement.

comb. The subsamples from both sides of the same comb were pooled for the three row diagonals. For this purpose rows on one side of the comb were chosen for reference and pooled with parallel rows from the other side. For example, 60° rows on one side were pooled with rows at 120° on the other side. Linear series of cells were selected from the same area of worker brood comb and chosen arbitrarily except that cells previously measured as well as visibly distorted cells were avoided. Measurements were made with a dial caliper and read to the nearest 0.1 mm. The span of 10 cell widths included 10 cell walls and followed the method of Rinderer et al. (1986): the distance included the wall of the first cell up to the near edge of the eleventh wall. The cells to be measured were conveniently marked in advance by placing small sticks in cell 1 and in cell 10.

Statistical analysis was performed with Statgraphics version 3.0 programs (Statistical Graphics Corporation) on an IBM PC/AT computer.

Results

The nest measured overall 78 cm from top to bottom, 50 cm in maximum width, and approximately 22 cm thick, including the "bee space" between combs. The nest was supported at the top by two branches of the tree, of which the main supporting branch was 5 cm in diameter. At the attachment of the nest to the branches of the tree were some short, convoluted combs at different compass orientations. The main body of the nest, however, consisted of eight parallel combs that were largely free of each other except for some connecting pillars and marginal attachments. The combs were mainly flat, but slightly wavy along the lower edges. The greatest widths of the combs were oriented at about a right angle to the main supporting branch and at a magnetic compass direction of 80°–260° or approximately east-west. This is contrary to the observations of Gambino et al. (1990) who found north-south orientations more common in feral nests in cavities. In

this nest the orientation was probably constrained by the orientation of the supporting branches.

As reported elsewhere (Taber & Owens 1970), both types of comb orientation can be found in a single nest. In the present nest, beginning on the north side: combs 1, 5, and 8 were nearly vertical in orientation and combs 2, 3, 4, 6, 7 were nearly horizontal. Combs 3 and 5 were divided in the middle into two subequal halves by a narrow, vertical, linear gap. Comb 5 had evidence of two old queen cells on the edges of the median division. Dead worker brood was found in central areas on both sides of combs 4, 5, and 6. Patches of drone cells and capped cells with honey were peripheral to the central brood areas. Pollen was stored in some cells of combs 3 and 7 just opposite to the brood areas. The remainder of the combs had empty cells of varying dimensions.

The overall distribution of 90 measurements of 10 worker brood cells each (total of 900 cells) was normally distributed ($\chi^2 = 9.98$, 6 df, $P = 0.12$) and with a mean $\pm$ standard error of 52.7 mm $\pm$ 0.281 mm and range of 46.8–61.3 mm.

When the distribution was divided into nine groups on the basis of comb number and row orientation, each with 10 measurements of 10 cell widths, a one-way analysis of variance indicated highly significant differences existed among the groups ($F = 33.9$, $df = 8$). Inspection of a notched box-and-whisker plot (Fig. 2) of the same nine distributions indicated that the median widths of cells in the 0° rows of combs 4 and 5 were significantly larger than median cell widths measured in all other orientations. The notch in each figure corresponds to the width of the 95% confidence interval for the median. In pairwise comparisons, notches that do not overlap are considered significantly different at the 5% level. The "box" corresponds to the central 50% of diameter values, the middle horizontal line is the median and "whiskers" mark the range of diameter values and outliers. The corresponding means of 10 measurements of 10 cell widths for each comb and row combination are, from left to right (Fig. 2): 56.6 mm, 50.65 mm, 51.83 mm, 56.34 mm, 52.90 mm, 49.57 mm, 53.27 mm, 50.48 mm, and 53.33 mm.

Discussion

Rinderer et al. (1986) describe the use of averages of three measures of 10 worker brood cells, regardless of row orientation, to identify European bees (averages of single cell widths: 5.2–5.3 mm) and Africanized bees (4.8–4.9 mm). The latter have average cell widths that are as much as 0.5 mm smaller than European bees. In the present nest, mean cell widths between rows of different orientation differ by as much as 0.7 mm. Although the overall average of worker brood cell widths for this nest is clearly in the range of European bees, the average width of 4.96 mm per cell for the 120° row of comb 6 is close to the values for Africanized bees. Hypothetically, if a feral nest of Africanized bees had a similar range of variation, some averages of cell widths might be large enough to be close to the averages of European bees.

If cell widths are to be considered for identification, then the procedure first recommended by Sylvester and Rinderer (1987) and demonstrated by Spivak et al. (1988) is recommended: 10 cells along each of the three diagonals are measured and the average used for identification. The cell rows should be selected well within the worker brood area and not in areas of honey storage or drone cells which are larger.

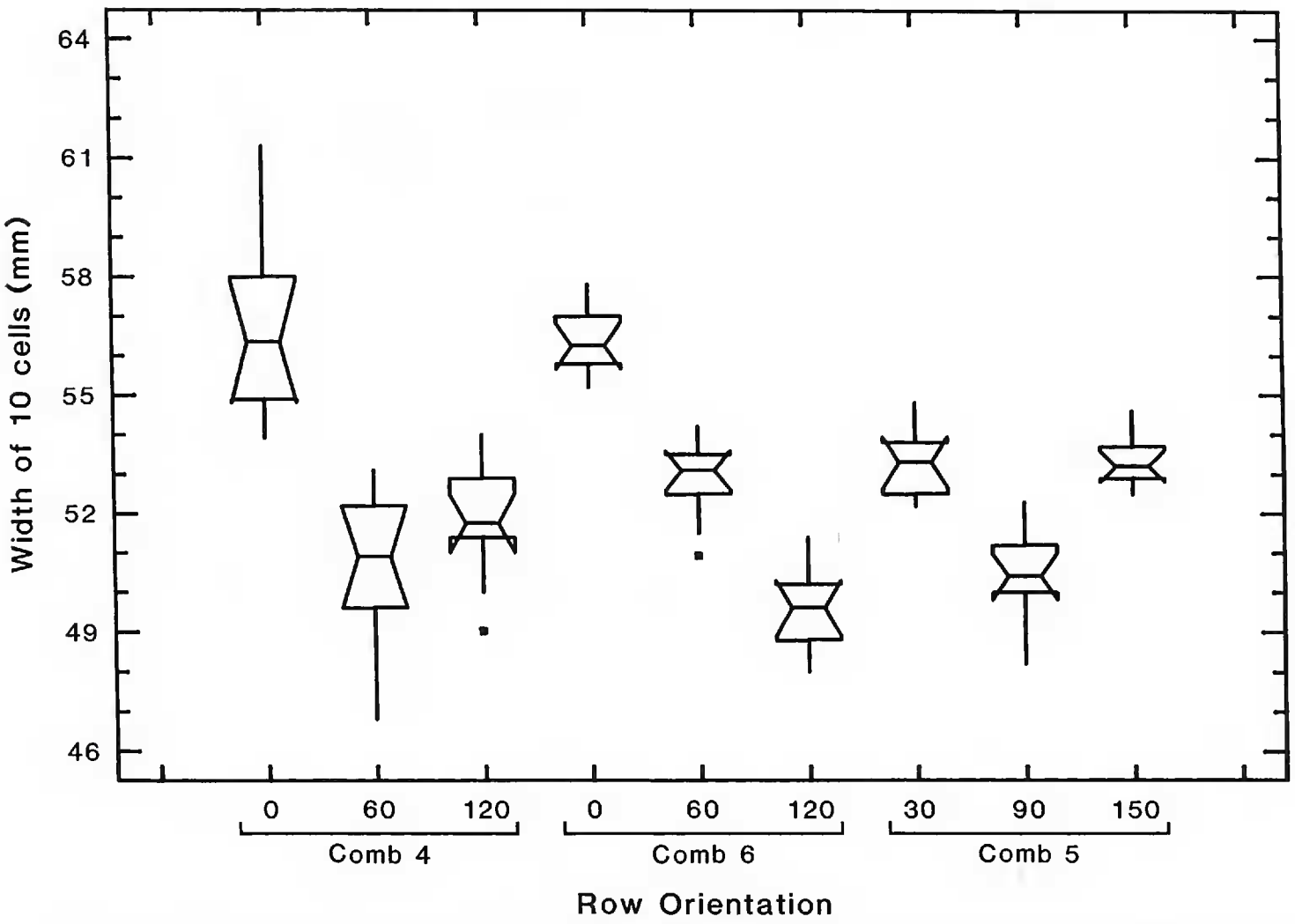

Figure 2. Notched box-and-whisker plot of distributions of measurements of 10 cell widths grouped by comb number and row orientation. See text for explanation.

Acknowledgment

I thank Arthur Slater and Stephen Comrie who removed the nest from the tree. John Barthell provided photographs of the nest *in situ* which confirmed the compass orientation of the combs. Marla Spivak commented on the manuscript and provided illustrations of comb orientation. Christina Jordan prepared the illustrations.

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